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ABSTRACT

While many studies have predicted elementary school achievement, few have investigated both cognitive and biographical predictors simultaneously in a multiple regression format. The present study used both types of variables in predicting achievement over a 20 month span. Criterion variables consisted of Stanford Achievement Test subscores, and a composite Stanford score, collected at the end of the first grade. Shrunken R's ranged from .60 to .76. Sex of student was the only biographical variable which consistently entered optimum prediction batteries. Implications for "sex" as a moderator variable and preventive programs for predicted low achievers are discussed. (Author)

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Multivariate Prediction of Early School Achievement[1]

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INTRODUCTION

In any program designed to reduce academic failure among school children, an important first step is to identify those students likely to encounter difficulty. Generally, the earliest opportunity to predict academic difficulty is upon entrance into a kindergarten program. There is currently a clear need to develop valid methods for the early prediction and identification of children expected to make unsatisfactory school progress. Smith and Keogh (1962, p. 639) stated that "The need for accurate early identification of potential reading problems and the optimal placement of children in a beginning reading program has been increasingly recognized."

A number of recent studies have shown strong relationships between certain cognitive variables and early school achievement (cf Bilka, 1971; Magoon, 1969; Gruen, 1972). The research has also given much attention to cognitive group tests (MacGinitie, 1969; Harris, 1969) as predictive devices for reading achievement, but the results have been suggestive and not specific in individualizing instructional programs (Barrett, 1965; Livo, 1970). Other researchers (MacGinitie, 1969; Farr, 1969) have suggested that there is a continuing need to explore and develop brief, group administered, and more powerful predictive

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instruments. In a study employing multivariate procedures, Gruen (1972) used a variety of perceptual-motor and cognitive-intellectual tests which resulted in multiple correlations ranging as high as .80. However, Gruen did not consider the inclusion of biographical variables as predictors.

Biographical data as predictors of academic success at the college level have shown fairly positive results (Anastasi, Meade, and Schnieders, 1960; Barger and Hall, 1965; Fricke, 1963; Starks, 1967; Woods, 1963) but Aiken (1964) felt such variables were situation - specific and declined in predictive efficiency when used in a situation different from the one in which it was validated.

Although a few studies (Henderson, 1968; Miller, 1970) have shown the importance of biographical data (i.e. parent's educational status) in predicting elementary school achievement, this information has seldom been combined with cognitive variables in an multivariate procedure. Biographical data are among the most easily gathered predictive information. These data can be efficiently and economically collected at the beginning of school directly from the registration form. The easy accessibility of biographical information should be underscored. If biographical data contribute as much to prediction as psychometric instruments which may take more time to administer and are relatively expensive, then the investigation of the predictive validity of biographical data will have been well worth the effort.

One difficulty in the prediction of academic success is the continued use of univariate prediction techniques. Lavin (1965) pointed out that, despite the availability of multivariate techniques, most predictive studies continue to employ univariate methods such as simple correlations between predictors and criterion. A continuing survey of prediction literature reveals a trend toward multivariate methods, but shows that most researchers still use univariate techniques. The strength of the multivariate techniques is that they permit the combination of variables in predicting a criterion, and also allow the efficient elimination of those variables which do not aid in prediction.

Few investigations have sought to compare the relative efficiencies of perceptual, cognitive and biographical predictor variables in combination, particularly at the primary grade level. The present research was designed to determine the relative contributions of selected perceptual, cognitive, and biographical variables in predicting first grade achievement from a battery of measures gathered at the beginning of kindergarten. A second major purpose of this study was to establish the predictive validity of an experimental readiness test which is comprised of items from several school readiness tasks. It should be pointed out that a primary consideration throughout this research has been the development of a screening battery which can be easily and economically obtained at the beginning of a child's educational experience.

Method

Subjects. The original sample consisted of 14[illegible] kindergarten students from a suburban Northeastern community in 1970. Because of attrition criterion data were collected in 1971 on a final sample of 104 students.

The school district employed in this research serves a cross-section of socioeconomic levels.

Measures: A battery of predictor variables (see Table 1) were gathered by a variety of school personnel which included teachers and specialists. At the beginning of the kindergarten year the subjects were administered a visual-motor perceptual test (Berry, 1967), a test of language development (Dunn, 1965), a figure drawing test (Hildreth, Griffiths, and McGauvran, 1969) and a locally developed academic readiness test (Shack, 1970). Biographical information generated three additional predictor variables: sex of student, and mother's and father's educational level. The Stanford Achievement Test, which served as a criterion measure, was administered at the end of the first grade by the school district, about 20 months after prediction data were collected.

Insert Table 1 about here

Berry Test of Visual Motor Integration: This is a test which involves copying a series of geometrical designs and purports to assess eye-hand coordination. In the present study the Berry raw score, as outlined in the published manual, was used as a predictor variable.

Peabody Picture Vocabulary Test: This test is a measure of receptive language and assesses language development. The student is presented with four pictures on a single page and asked to identify which is related to the word verbalized by the examiner. The Peabody raw score calculated according to the published manual was used in the present study.

Figure Drawing: The subject is requested to draw a picture of a man. The productions are scored according to the published criteria of the Metropolitan Readiness Test.

East Windsor Readiness Test (EWRT): This is a test composed of six subtests, three of which reflect letter knowledge and three of which reflect knowledge of numbers. Responses to this individually administered instrument involve a variety of sense and perceptual modalities. This test is based on the rationale that a child's ability can be best predicted by a test which contains actual items selected from the universe of the area to be predicted. The total administration time is about five minutes. The first section, which reflects letter knowledge, includes:

1. Letter Recognition: The examiner verbalizes five letter names and asks the student to locate the appropriate symbolic representation from a sheet depicting five letter symbols.

2. Letter Naming: The examiner points to five letters and requests the student to identify the symbols by their letter name.

3. Letter Writing: The student is directed to write five letter symbols identified by the examiner by their letter names.

The second section, which reflects number knowledge, includes:

1. Number Recognition: The examiner verbalizes five number names and asks the student to point to the appropriate symbol.

2. Number Naming: The examiner points to five numbers and requests the student to identify the symbols by their number names.

3. Number Writing: The student is directed to produce five number symbols verbalized by their number names.

Each of the six subtests consist of five responses with a correct response worth one point. The maximum possible score is a total of thirty points.

Reversals: This is a count of the number of reversals, i e., symbols produced in the mirror image, from the letter and number writing tasks of the East Windsor Readiness Test. Reversals are disregarded for scoring purposes on the EWRT.

Biographical Variables: The following biographical variables were gathered from available registration forms and school records:

Sex of the student

Mothers' education level (highest grade attended)

Fathers' education level (highest grade attended)

Stanford Achievement Test (SAT): This is a group administered normative referenced instrument given to all students in this school district at the end of the first grade. It is scored by computer and entered into the academic file upon receipt of the test scores. The standard scores of the various SAT subtests served as criterion measures for the present study.

The Primary I form of the SAT used at the first grade level consists of five subtests that focus on the language arts skills (Word Reading, Paragraph Meaning, Vocabulary, Spelling, Word Study Skills) and one subtest that assesses arithmetic abilities (Arithmetic). The sum total of the standard scores generated an additional criterion variable.

Statistical Analysis

Data were analyzed by means of stepwise multiple regression techniques, and optimum sets of predictors were identified. An optimum battery of predictors is defined as that combination of variables which predicts the criterion with a minimum standard error of estimate. An outcome of the stepwise method is that each variable is rank ordered in terms of its ability to identify criterion variance. To achieve some sort of overview about the importance of each predictor, the rank order of each predictor's entry into regression equations was tallied across each of seven criteria. In this way, the sum of the ranks indicated the usefulness of each predictor in accounting for criterion variance.

Ranks were generated by assigning point values to the order of entry of each predictor into the regression equation within the stepwise format. Thus, a predictor which entered the equation first was given six points, a second place entry was given five points, and so on. Finally, because a cross-validation sample had not been available, Lord's formula (1950) was applied to the multiple correlations to estimate the amount of shrinkage which would occur in a new sample.

RESULTS

Results of the multiple regression analyses of the eight predictor variables with respect to each Stanford subtest and the sum of the scaled scores are presented in Table 2. Multiple R's ranged from .65 to .74, for predicting the Stanford subtests using an optimum battery of variables, with a median R of .67. In predicting the sum of the Stanford scaled scores, a more reliable criterion, an R of .78 was obtained.

Insert Table 2 about here

Since cross-validation procedures were not employed, shrunken multiple correlations were estimated using Lord's (1950) formula[1] and yielded R's ranging from .60 to .70 with a median of .62 for the Stanford subtests and a shrunken R of .76 for the sum of the subtests.

The rank order of the predictor variables accounting for criterion variance are presented in Table 3. The total score on the East Windsor Readiness Test and the raw score on the Peabody Picture Vocabulary Test,

Insert Table 3 about here

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[1] $\bar{R} = \sqrt{1-[(1-R^2)\cdot \frac{N-1}{N-m-1}]}$

two cognitive measures, clearly earned the most points as they consistently appeared in the first or second position in the optimum batteries. Sex, the only biographical variable to consistently appear in the optimum batteries, ranked third in accounting for criterion variance.

Because of the relatively high ranking of sex as a predictor variable, it was treated as a moderator variable in subsequent analyses. In other words, the predictions were run for males and female subjects separately. Results of the stepwise analyses within sex are shown in Tables 4 and 5. It can be seen that obtained R's were not substantially improved by using sex as a moderator. Shrunken R's for the male

Insert Tables 4 and 5 about here

sample ranged from .60 to .78, with a median R of .70; for the female sample, the range was from .33 to .72, with a median R of .71. Despite the negligible increase in predictive efficiency when using sex as a moderator, another important finding was discovered. The rank ordering of predictor entry into optimum batteries was considerably different between males and females. The male Ss generated rankings quite similar to the combined sample, but the predictor ranks for female Ss were shifted (see Table 3). It appears that the Peabody was the best predictor within females Ss, while the East Windsor Readiness Test was best for male Ss. Because of the poor subject-to-predictor ratio obtained when predicting within sex, it must be acknowledged that the resultant regression equations are likely to be spuriously high. Thus, the shrunken Rs reflect, in some cases, relatively large estimates of shrinkage in a cross-validation sample.

DISCUSSION AND CONCLUSIONS

This research was concerned with determining an optimum set of cognitive and biographical predictors which can predict school achievement at the primary level. The results indicate that first grade achievement can be effectively predicted using a combination of variables.

The East Windsor Readiness Test, an experimental instrument, appeared to be the best and most consistent predictor of achievement scores with the Peabody Picture Vocabulary Test running a close second place. Sex ranked third across all predictors in accounting for criterion variance.

Shrunken multiple correlations suggested that minimal shrinkage would occur with a cross-validation sample. Such a cross-validation study is currently in progress and additional predictors have been included in an attempt to further improve prediction.

With the current press toward individualized instruction, one possible outcome is that the underachiever or slow learner will have remedial programs "custom built" for his particular needs. Yet, remedial programs are not, and never have been a sufficient means for helping children with learning difficulties. One major problem with remediation techniques is that they must ordinarily wait until the dysfunction is discovered. It seems likely that the later the dysfunction is discovered, the more difficult the remediation process. An alternate, or supplementary method of assisting youngsters is to predict those likely to have difficulties, and to institute preventive programs.

Identification of learning problems can be a costly procedure. A large number of referrals at the primary school level are usually concerned with achievement problems, or behavior problems related to

academic failure. The relative scarcity of psychologists and other pupil personnel specialists suggests the need for a screening technique which is economical in cost, time, and manpower. With such a technique, the psychologist's time can be used more efficiently and he can make more effective use of his skills.

If the individualized instruction is to be considered as desirable it must consider differences among children which are pertinent to learning. After differences are identified, the deficits should be dimished by programs designed and tailored in accordance with the differences. Children who are identified by efficient prediction procedures as likely to have academic difficulty may be referred for further diagnostic evaluation to determine competencies regarding specific sensory, perceptual, affective and cognitive factors. School failure can thus be prevented to some extent by early intervention which leads to more individualized instruction.

Educational researchers have studied the relationships between sensory preferences and academic performance (e g., Benger, 1968; O'Connor, 1969) with the assumption that some students are "visual" learners and others "auditory" learners. Hence, the reading approach would be "sight" or "phonic" depending on the child's preferred modality. According to Zigmond (1969), reading at the decoding level involves the relationsips between auditory patterns and spatially-ordered visual patterns. Thus if a child lacks the skill to analyze phonic elements, the "sight" approach may be inappropriate since it is dependent upon letter-sound relationships.

Traditionally, the elementary school provides a single program in reading for all students. While in some cases the rate of learning is varied, there is seldom an attempt to individualize the instructional content to accommodate the child's needs. If the data in this study are replicable and the results reliable, it may be reasonable to suggest that a phonics approach to reading would serve the majority of students since auditory reception skill was a strong predictor of achievement success. In a recent study by Hosner (1973), a similar conclusion was suggested as a result of the strong relationship he found between his auditory perceptual test and the language arts subtests of the Grade 1 Stanford Achievement Test. A direct implication is the need for preventive training in the auditory skills as indicated by low scores on the present battery to prepare the child for phonics before placement into a reading program. If there is a need for accommodation or variation, this should occur within the phonics program with the use of teaching devices (e.g. language master), that could supplement the program.

In summary, although there have been literally hundreds of studies predicting academic success, it is a rare occasion which finds prediction of achievement yoked to actual preventive techniques. The present study, then, is an attempt to begin a series of programmatic research which will not only identify and cross-validate optimum prediction batteries for young children, but also emphasize the preventive aspects of such research.

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Table 1

Predictor Variables

1. Berry Test of Visual Motor Integration (BRS)
2. Peabody Picture Vocabulary Test (PBS)
3. Figure Drawing subtest of the Metropolitan Readiness Test (FD)
4. East Windsor Readiness Test (EWRT)
5. Number of Symbol Reversals on the EWRT writing tasks (REV)
6. Sex of Student (SEX)
7. Mother's Educational Level (highest grade) (MEL)
8 Father's Educational Level (highest grade) (FEL)

Table 2

Rankings of Predictors in Identifying Criteria Variance (N=104)[1]

Criterion: Stanford Achievement Test; Primary I	Mult. R	Order of Predictor Entry into Optimum Battery 1st	2nd	3rd	4th	5th	6th
Word Reading	.65	EMRT	PRS	SEX	REV	—	—
Paragraph Meaning	.74	EMRT	PRS	FD	BRS	REV	—
Vocabulary	.67	PRS	EMRT	FEL	SEX	REV	—
Spelling	.73	EMRT	PRS	SEX	REV	FD	FEL
Word Study Skills	.67	EMRT	PRS	SEX	REV	FD	—
Arithmetic	.66	PRS	EMRT	MEL	FD	SEX	—
Sum of Standard Scores	.78	EMRT	PRS	SEX	FD	REV	—

[1]Predictors were as follows: EMRT = East Windsor Readiness Test; PRS = Peabody raw score; SEX = sex of student; REV = number of reversals on EMRT; FEL = father's educational level; MEL = mother's educational level; FD = figure drawing portion of Metropolitan Readiness Test; BRS = Berry raw score.

Table 3

Rank Order of Predictor Variables in Accounting for Criteria Variance

Predictor	Sum of Points[1] Combined Sample	Males	Females
1. East Windsor Readiness Test	40	40	27
2. Peabody Picture Vocabulary Test	37	36	38
3. Sex	21	—	—
4. Number of Symbol Reversals (from the EWRT)	15	16	8
5. Figure Drawing	14	18	13
6. Father's Education Level	5	4	11
7. Mother's Education Level	4	3	5
8. Berry Test of Visual Motor Integration	3	0	7

[1]Points were accumulated as follows: first place entry into the regression equation is 6, second place is 5, third place is 4, fourth place is 3, fifth place is 2, sixth place is 1.

Table 4

Rankings of Predictors For Male Subjects (N=68)

Criteria	Multiple R	1st	2nd	3rd	4th	5th
WR[1]	.72	EWRT	PRS	REV	—	—
PM	.73	EWRT	REV	PRS	FD	—
V	.63	PRS	EWRT	FEL	REV	—
SP	.70	EWRT	PRS	FD	—	—
WSS	.71	PRS	EWRT	FD	—	—
AR	.66	EWRT	PRS	FD	MEL	—
SUM	.80	EWRT	PRS	REV	FD	—

Table 5

Rankings of Predictors For Females Subjects (N=36)

Criteria	Multiple R	1st	2nd	3rd	4th	5th
WR	.43	EWRT	PRS	FD	—	—
PM	.77	EWRT	FD	PRS	BRS	FEL
V	.74	PRS	FEL	EWRT	—	—
SP	.75	EWRT	PRS	FEL	REV	—
WSS	.47	PRS	REV	—	—	—
AR	.70	PRS	MEL	BRS	—	—
SUM	.74	PRS	EWRT	FD	—	—

[1]Abbreviations are as follows: WR = Word Reading; PM = Paragraph Meaning; V = Vocabulary; SP = Spelling; WSS = Word Study Skills; AR = Arithmetic; SUM = Some total of the standard scores